ASSESSMENT AND MODELLING OF WATER QUALITY NEAR MINE SITES

A THESIS SUBMITTED IN PARTIAL FULLFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology

In

Mining Engineering

By

MANISH HOTA

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DEPARTMENT OF MINING ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

ROURKELA – 769008

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CERTIFICATE

This is to certify that the thesis entitled **"Assessment and Modelling of Water Quality near Mine Sites"** submitted by Sri Manish Hota (Roll No. 110MN0614) in partial fulfilment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at the National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

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ACKNOWLEDGEMENT

First of all, I would like to express my deep sense of respect and gratitude towards my advisor and guide Prof. H B Sahu, who has been the guiding force behind this work. I am greatly indebted to him for his constant encouragement, invaluable advice and for propelling me further in every aspect of my academic life. I consider it my good fortune to have got an opportunity to work with such a wonderful person, not just professionally but personally as well.

Apart from him, we feel grateful and obliged to Sri B.N. Naik, Technical Assistant for his help in carrying out some of the experiments at the laboratory. I thank Sri Bishnu Prasad Sahoo, Ph.D. Research Scholar, without whose help this work would not be possible.

I thank each and every faculty of the Department of Mining Engineering, National Institute of Technology, Rourkela from the bottom of my heart. They have been great sources of inspiration, knowledge and encouragement throughout the course of my Bachelor's Degree.

Last but not the least, my sincere thanks to all my friends who have patiently extended all sorts of help for accomplishing this dissertation.

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ABSTRACT

Introduction:

One of the real effects of mining techniques is the defilement of water bodies through mine water waste, spillage of water presented to minerals, water from soil stacks, corrosive mine seepage and mine water rebound. Water is the most critical component of eco-framework and it is subsequently basic to focus and moderate the impacts of mining operation on the same. Additionally, contaminated water has a lot of physical, chemical and physiological consequences for all living creatures. For this, it is imperative to distinguish the critical parameters in the water test which is the extent of the study.

Sampling:

Samples are collected from different locations near iron-ore mines spread in Sundargarh district of Odisha. Both surface and ground water samples are collected to check whether mining activities is having some impacts on them or not. The samples are analysed through a series of experiments for assessing the physical and chemical parameters such as pH, Turbidity, TDS, DO, BOD, Nitrate, Sulphate, Chloride, Conductivity etc. After determining the parameters, the water quality index is being found out to assess the pollution efficiency of the water samples. Water quality index is one of the most used tool of water quality modelling. There are a lot of water quality index used now a days. Among them two most reliable are being used for the analysis of the samples. They are

1. National Sanitation Fund Water Quality Index (NSF-WQI)
2. Weighted Arithmetic Water Quality Index (WA-WQI)

Observation:

As per Weighted Arithmetic Water Quality Index (WA-WQI) Model is concerned, the WQI values of all the 8 samples are as follows:

Sample No.	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8
WA WQI Value	51.832	46.950	55.628	33.231	37.941	20.152	32.491	35.46

Conclusion:

As seen from the table, the surface water i.e. from either nallah or any mine is much more polluted compared to ground water. The sample collected from the mine i.e. S-3 is very contaminated and can't be used for drinking purpose. While the ground-water samples collected are pure and can be utilized for drinking purpose. The bore-well water i.e Sample-6 is found to be the purest of all the samples. It can also be used for drinking purpose. As per pH standard is concerned, except S-4 and S-5 every sample is within limits. But all eight samples have higher turbidity values as per the standard is concerned. S-1, S-3, S-4 and S-5 have got high hardness values compared to other 4 samples. As per DO is concerned, DO of all samples is greater than 5mg/L, the standard. Even sulphate concentration of all samples are within standards except S-5. The bore-well water i.e. Sample-6 is found to be the purest of all the samples. It can also be used for drinking purpose. Both the WQI models gives different values since they are considering different parameters in their models.

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CHAPTER-1

INTRODUCTION

1. INTRODUCTION

Water contamination is a significant worldwide issue which obliges continuous assessment and amendment of water asset strategy at all levels. It has been seen that it is the heading overall reason for deaths and diseases, and that it represents the deaths of more than 14,000 individuals every day. An estimated of 580 individuals in India pass on of water contamination related disease consistently. Notwithstanding the intense issues of water contamination in developing nations, developed nations also keep on strugging with contamination issues too. Water pollution is also caused by mining activities carried out in the nearby areas. The mining processes influences and many times worsens the environment in numerous ways.

The main sources of such pollution are mine water drainage, leakage or flow of mineral exposed water to the surface or to nearby located aquifer system and surface water body, water from spoil heaps and spoil heap failures, acid mine drainage and mine water rebound. These causes can be lively in all mines whether working or abandoned. These types of sources result in various types of water pollution viz. acid mine drainage, heavy metal contamination and leaching, processing chemical pollution, or erosion and sedimentation. Even the tailings coming from the processing plants can affect the surface or ground water very badly if it comes in contact of it.

The release of mining waste to the environment can result in intense devastation of ecology, which in some cases may not be fully restored or reformed. The impact of discharges containing metals and heavy metals on receiving streams is unpredictably broad to realize. Health hazards of user of such water, demolition of aquatic flora and fauna, shocking aesthetic impact are some typical aspects of the broader view. Severe mine water discharges threaten water supply in many areas for house hold, irrigation or even construction purpose. It is therefore essential to carry out water quality studies and its fitness for various applications; otherwise its use may lead to disastrous consequences in the long run. Most importantly, if water is used for drinking or any household purpose, it must satisfy the drinking water quality standards else it can have

an adverse effects on human health.

1.1 OBJECTIVES OF THE STUDY:

Keeping the above problem in mind, the following objectives have been planned.

1. To collect water samples from mining areas.
2. To analyze the water samples for evaluating the physical and chemical parameters.
3. To identify the most polluting component in the samples and also to identify its source.
4. To estimate the extent of quality of all the samples using water quality index.

CHAPTER-2

LITERATURE REVIEW

2. LITERATURE REVIEW

Leitz (1976) demonstrated the Electro-dialysis process for water clean-up. In water, a salt dissolves to produce positively charged cations and negatively charged anions. If an electrical field is placed across the solution, the cations migrate toward the negatively charged cathode while the anions migrate in the opposite direction toward the positively charged anode. He used this concept in desalination of water. Electro-dialysis apparatus, a stack of rectangular membranes terminated on each end by an electrode, is used for the purpose. It is followed with ion-exchange where purer water is required. The water formed from it finds application in petroleum refining, petrochemical production, automobile manufacturing, and mining (as boiler feed, cleaner for manufactured parts, cooling water etc.). Even this process can be used underground as an alternative to the transportation of fresh water from other places.

Robeck et al. (1989) endeavored for the removal of pesticides after DDT started demonstrating its adverse impacts on non-target life forms. They found that the latest pesticides like Endrin and Endosulfan are degradable to some degree compared to DDT and Dieldrin. They coagulated the examples with alum and different polymers and got a few effects. They examined the evacuation of pesticides by routine water medicine procedures, for example, alum coagulation, illumination, softening, re-carbonation and chlorination. They presumed that the evacuation of these pesticides were inconsequential, stressing and there is the requirement for the improvement of more solid innovation.

Norris et al. (1990) studied the monitoring programs in Colorado and Ohio to find the effective management of water resources. They collected 3,08,000 samples from Colorado and 1 million from Ohio via different sources. They had done a phase by phase water assessment program. In the phase 1, they identified and estimated the costs of water quality data collection programs and pointed out those data that satisfy the requirements for broad scale water quality assessment. In phase 2, they evaluated the extent to which the data can be useful in addressing the water quality issues for the two states. Only 34% of samples collected from Colorado and 5% of samples from Ohio met the screening criteria. They found out an apparent imbalance in the areal and temporal scales of the assessments. For large areas, the information provided by

the monitoring programs was inadequate to perform an unbiased assessment of regional surface water and groundwater quality conditions.

Singh (1990) displayed the status of water quality and its inclination in the Jharia Coalfield-where about thirty real businesses (for the most part expansive measured and coal based) remove water in addition to the extensive coal mining exercises. This study revealed that water is horribly contaminated in the whole coal mining zone. They accounted a list of major sources which bring about water quality deterioration in the district as handling plants, mining activities are being done in that area.

Jambrik and Bartha (1994) concentrated on the first and auxiliary impacts on ground water quality by mining in the East Borsod Coal Basin, Hungary. They found that in very nearly all Hungarian coal basins, excess dewatering brings down the hydrostatic pressure of aquifers, diminish their water assets, unbalance water administration of the region, and pollute it.

Tiwary and Dhar (1994) assessed the water quality of Damodar in a stretch of 50 km in Jharia coalfield area with particular reference to heavy metals. Sediments of the river bed was portrayed for substantial metals, Iron, Manganese, Cadmium, Chromium, Nickel and Lead determine total carry-over of heavy metals in the river body. Substantial metal concentration in the stream residue were higher than in the waterway water. The study additionally demonstrated that Iron and Manganese were irreversibly held in the residue and this impact was likewise observed for different metals in decreasing order: Lead, Chromium, Nickel and Cadmium.

Singh (1997) carried out a number of experiments and found out that the major reasons of water pollution in mines are contamination of water bodies due to discharge of mine water effluents, leachates from wash-off dumps, solid waste disposal sites, broken rocks, toxic wastes, salinity from mine fires, acid mine drainage etc. He listed the major mitigation methods as follows: Overburden run-off collection and treatment with subsequent sediment control, Oil and grease separators, Collection/storage of leachates, seepages, wash-offs with subsequent treatment, Proper sanitation and provision of domestic and sewage effluents treatment, treatment of mine water discharges.

Smith and Haque (1998) studied the drinking water of Taiwan and Argentina and suggested that ingestion of inorganic arsenic from drinking water resulted in increased risks of internal cancers, particularly bladder and lung cancer. They also did an investigation regarding arsenic levels in water and cancer mortality in a region of Northern Chill. Population-weighted average arsenic levels reached 570 μg/litre between 1955 to 1969.Standard Mortality Rate (SMR) is a quantity, expressed as either a ratio or percentage quantifying the increase or decrease in mortality of a study with respect to the general population. If it is higher than 1.0, then there is a higher number of deaths than is expected. Increased mortality was found for bladder, lung, kidney, and skin cancer. Bladder cancer mortality was markedly elevated (men, SMR = 6.0 (95% confidence interval (CI) 4.8–7.4); women, SMR = 8.2 (95% CI 6.3–10.5)) as was lung cancer mortality (men, SMR = 3.8 (95% CI 3.5–4.1); women, SMR = 3.1 (95% CI 2.7–3.7)).It was also estimated that arsenic might account for 7% of all deaths among those aged 30 years and over.

Ghose and Sen (1999) did some experiments regarding impact on surface water quality due to the disposal of tailings. For the tailings to restrict to mingle with the ground water, provision of tailing pond for the containment is a must. Even it does not give the full guarantee of environmental compliance. Huge quantity of water is needed for the beneficiation of iron ore, so after the beneficiation, water with tailings are processed into the pond and water should be recycled using a thickener. This would help in the effective usage of water. Generally water pollution is due to the presence of suspended solids if the processing of tailings is not proper. Serious concern in this regard is the direct discharge of tailings into rivers. To assess the impact on surface water quality, they collected samples from the river, nallah near the iron ore mine in Sundergarh district. Some parameters like temperature, pH and dissolved oxygen are measured at site while others (chemical o2, hardness, general metals) are measured later on. They also found other trace metals contaminating the surface water, even if they were present within the permissible limits.

Hopke et. al. (2000) sorted out the health risks due to radon present in drinking water. Generally it came to mingle with drinking water from the indoor air, though its conc. is less. Of all the radioactive isotopes, Radon presents the largest risk to human health. The risk posed by radon released from water, even at typical groundwater concentrations, was estimated to be larger than the risks posed by the other drinking water contaminants that have been subjected to regulation. Radon in water also presents a direct ingestion risk. The risk of cancer arose from

the ingestion of radon dissolved in water. The R-particle produced multiple sites of DNA damage resulting in deletions and rearrangements of chromosomal regions and leading to the genetic instabilities implicated in tumour progression. Once radon has entered the blood, through either the stomach or the small intestine, it is distributed among the organs and it was very dangerous then.

Baba et. al. (2003) studied the effect of Yatagan Thermal Power Plant (Mugla, Turkey) on the quality of surface and ground waters. Their study revealed that the concentrations of Ca2+, Cd2+, Pb2+, Sb2+ and SO4 2- in some samples exceed the Drinking Water, U.S. EPA and WHO limits. Isotope analyses were carried out to determine the origins of waters, which showed that contamination is taking place in the vicinity of the waste disposal site of power plant.

Qian et. al. (2007) made surface water quality evaluation using multivariate methods and a new water quality index in the Indian River lagoon, Florida. They put 6 stations at 6 locations and continuously monitored then. They used Clustering method to cluster the 6 monitoring stations in 3 groups with stations on the same or characteristically similar stations in same group. Then they carried out the evaluation of the groups and found out the results of water quality.

Kar et. al. (2008) studied the assessment of heavy water pollution in surface water. They gathered what added up to 96 surface water samples from river Ganga in West Bengal throughout 2004-05 and studied for pH, Electrical Conductivity (EC), Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Cadmium (Cd), Chromium (Cr), Lead (Pb) and Nickel (Ni). They found that among the substantial heavy metals themselves, a significant negative correlation was observed between Fe and Cr, whereas Ni exhibited a significant positive correlation with Mn and Zn.

Bishnoi and Malik (2008) studied the systematic physico-chemical analysis of the groundwater at 41 different locations in Panipat city (Haryana), India to evaluate its suitability for domestic purposes. Their study revealed considerable variations in the water samples with respect to chemical composition and they found that all samples have high concentration of dissolved salts and all the samples were very hard.

Ramakrishnaiah and Ranganna (2009) assessed water quality index for ground water of tumkur taluk, Karnataka. They collected groundwater samples and carried out a physiochemical analysis on the samples. For calculating the WQI, they considered the 12 parameters, viz. pH, total hardness, calcium, magnesium, bicarbonate, chloride, nitrate, sulphate, total dissolved solids, iron, manganese and fluorides. The WQI for these samples ranged from 89.21 to 660.56. This analysis revealed that the groundwater of the area needed some degree of treatment before consumption, and it also needs to be protected from the perils of consumption.

Gendren et. al. (2009) found that ambient concentrations of metals in surface waters have become an important consideration when establishing water quality criteria and conducting risk assessments. Their study involved the estimation of amounts of copper that may be released into fresh and estuarine waters considering ambient concentrations, toxicity thresholds, and bioavailability. Cumulative distribution functions of ambient copper concentrations were compared statistically for individual sites within 14 surface water samples of North America and Europe to identify differences among mean distribution variables.

Tiri and Boudoukha (2010) studied the quality of water surface of Koudiat Medouar dam. They analysed the water condition and the results revealed that surface water quality was mainly controlled by geology, agricultural uses and domestic discharges. They also found that water is heavily influenced by geology, and by traces of metals (iron, lead), and also marked by high levels of nitrate, ammonium and sodium due to urban pollution.

Liu et al. (2011) gave an approach for improving water quality management in mining. The potential environmental threats posed by freshwater withdrawal and mine water discharge are some of the main drivers for the mining industry to improve water management. The use of multiple sources of water supply and introducing water reuse into the mine site water system should be employed by the mining industry. However, a barrier to implementation of such good water management practices is concomitant water quality variation and the resulting impacts on the efficiency of mineral separation processes, and an increased environmental consequence of noncompliant discharge events. In this paper they proposed an approach that could assist mine sites to manage water quality issues in a systematic manner at the system level. Water is simultaneously moved to processing plant, mine workings, tailings from the blender

(comprising of fresh water). The worked water is purified and again sent to the blender while the water rescued from the processing plants in the mid is moved directly to the blender without any purification. This approach can quantitatively forecast the risk related with water quality and evaluate the effectiveness of management strategies in mitigating the risk by quantifying implications for production and hence economic viability.

Jordaan (2012) had indicated the water quality of Oil Sands processing in Alberta. Growth of oil sands progress caused not only in the release of green house gas outflows, but also affects land and water assets. The surface water devoured by oil sands operations is a prime case of this marvel. The surface water prerequisites for oil sands is substantially more contrasted with that for horticulture reason. The northern stream bowls of Alberta, where oil sands stores are arranged, have a relative plenitude of water as opposed to the south where water is as of now rare and there is critical farming advancement. With the expansion in oil sands generation, water utilization additionally climbs. Water accessibility in the Athabasca River is relied upon to decrease because of environmental change later on while oil sands improvement grows. Withdrawals throughout this time may influence a bigger part of fish environment and abatement the measure of broke down oxygen accessible to fish in the winter. Easier levels of broke down oxygen may defer incubating, change the mass of post incubated fish and change generating periods for specific types of fish. Hoisted levels of Polycyclic Aromatic Compounds (Pacs) had been found in the water tests. Despite the fact that the Pacs were not found to arrive at close-by groups in this study, they were discovered to be at levels sufficiently high that are likely poisonous to fish developing lives. A second study demonstrated that the levels of seven toxins (cadmium, copper, lead, mercury, nickel, silver, and zinc) were found to have surpassed Canada or Alberta's rules for the assurance of amphibian life.

Akcil and Koldas (2006) observed that the major proportion of water is polluted becoz of Acid Mine Drainage. They found that Acid Mine Drainage (AMD) is produced when sulfide-bearing material is exposed to oxygen and water. Iron sulfides along with other metal sulfide minerals may also produce AMD. It has low pH, high specific conductivity, high concentrations of iron, aluminum, and manganese, and low concentrations of toxic heavy metals. They found that factors like pH, temperature, Oxygen content of the gas phase, Oxygen concentration in the water phase, Degree of saturation with water, Chemical activity of Fe^{3+}, Surface area of exposed metal sulphide, Chemical activation energy required to initiate acid generation and

Bacterial activity influenced the rate of acid generation. They pointed out that AMD can be controlled by:

- Diversion of surface water flowing towards the site of pollution using ditches or sth else
- Prevention of groundwater infiltration into the pollution site;
- Prevention of hydrological water seepage into the affected areas; and
- Controlled placement of acid-generating waste.

CHAPTER-3

IMPACTS OF MINING ON WATER QUALITY & ITS EFFECTS ON LIVING ORGANISMS

3. IMPACTS OF MINING ON WATER QUALITY & ITS EFFECTS ON LIVING ORGANISMS

3.1 USE OF WATER IN MINING

Mining operations use water for mineral processing and metal recovery, controlling dust, and meeting the needs of workers on site. The amount of water required by a mine varies depending on its size, the mineral being extracted, and the extraction process used. For instance, metal mines that chemically process ore to concentrate metals such as copper and gold use much more water than non-metal mines such as coal, salt, or gravel mines.

Although a large mining operation may use a considerable amount of water, the minerals industry overall consumes a relatively small quantity of water at national and global levels. Mining accounted for 4% of the water used in Canada in 2005, versus 60% for coal and nuclear electric power generation, 18.5% for manufacturing, 9.5% for municipal water supplies, and 8% for agriculture. Mining accounts for 1% of water used in the U.S., and 2-3% of the total water consumed in Australia.

3.2 EFFECT OF MINING ON WATER QUALITY

Although the mining and processing industries have provided many economic and societal benefits, they also have caused significant environmental impacts, including acid mine drainage (AMD) in some areas and contamination of groundwater, surface water, and soils. The degree and significance of AMD and metal contamination of water and soils are affected by complex biochemical reactions in the disturbed ore bodies and associated mine waste materials (tailings and waste rock).

Ground-water pollution can occur both directly and indirectly as a result of surface mining.

- **Direct degradation** can occur to ground water situated downhill or down gradient from a surface mine, by flow of contaminated drainage from the mine. This mine drainage can come from pits, ponds, or from rainfall infiltration and ground-water flow during

mining and after reclamation. Ground-water pollution would result from the same toxic overburden and coal materials that cause surface water contamination.

- **Indirect degradation** of ground water could result from blasting, which causes a temporary shaking of the rock and results in new rock fractures near working areas of the mine. Blasting can also cause old pre-existing rock fractures to become more open or permeable, by loosening mineral debris or cement in these fractures; this could affect nearly vertical fractures located up to several hundred feet away from the surface mine, causing vertical leakage of ponded mine drainage from nearby abandoned deep mines to underlying aquifers. These deep mines could be situated in the same coal seam being surface mined or in a lower coal seam.

The following are the points regarding effect of mining on water quality:-

1. The water present there can drive the **mobilization** and **transport of pollutants**, including metals, from source areas such as tailings and waste rock piles to ground and surface waters in the form of **non-point source pollution**.
2. Because of the mining activities, the water present near mine sites mostly have **higher hardness value** compared to its past stage. This potentially indicates pollution in these areas.
3. Along with hardness, surface water contaminated by mine drainage mostly has higher pH and lower acidity, total iron, manganese, aluminium, and suspended solids than untreated surface mine drainage
4. The primary sources of Manganese and Iron in the river water are the untreated industrial wastewater discharged from the CKF, tailings and waste rock associated with the Manganese or iron ore.
5. **In the wet-season** water near the mine sites carry enormous amounts of sediment loads. In a situation where opencast mining is being conducted, the sediment discharges could be order of magnitude higher in the wet-season compared to the dry season. It is thus advised not to take samples for water quality parameters during the crucial monsoon months.
6. **Tailings** are finely ground rock and mineral waste products from mineral processing operations. Tailings are usually deposited in the form of a water-based slurry into

tailings ponds, which are sedimentation lagoons, enclosed by dams built to capture and store the tailings else it can pollute the water to a great extent.

7. **Acid Mine Drainage** originates by geochemical reactions where pyrite from exposed coal or associated rocks reacts with oxygen gas and water to yield dissolved iron and sulphuric acid. The iron then further oxidizes to yield more acid and precipitated iron mineral solids. Further, dissolved oxidized iron can react with more pyrite generating more sulphuric acid. Mine drainage may then be artificially or naturally neutralized. Most mine drainage becomes at least partially neutralized by natural exposure to alkaline rocks and minerals even without any treatment by the coal mine operator. The strong acid may become partially neutralized primarily by solution of carbonate minerals (such as calcite and dolomite). This happens in the reclaimed mine site as well as in rock strata underlying the mined coal seam.

The potential for water contamination at a mine site depends on a number of factors:

- **Type of ore being mined**
  Some ores, such as sulphide ores, are more chemically reactive than others, and have a greater tendency to dissolve and contaminate water. Common contaminants that are present naturally in metal ores include metals, metalloids, and salts.
- **Chemicals used in the mineral preparation and metal extraction processes**
  Chemicals used to process metal ores include cyanide, sulphuric acid, and organic chemicals. A single mine may use a combination of physical and chemical processes to separate metals from ore.
- **Climate**
  The amount of water available and potential for contamination at a mine site can vary depending on the climate. For instance, mines in permafrost regions where the groundwater could be frozen would not have the same concerns for groundwater contamination as mines in warmer regions.
- **Life stage of the mine**
  Whether a mine is under construction, operating, or closed can affect its potential to contaminate water. For example, the potential for water contamination from process chemicals is minimal following the closure of a mine, but if the mine workings were to be subjected to natural flooding, minerals could dissolve and mix with the surrounding groundwater.

- **Environmental management practices in place**

  Modern water management practices and mine designs greatly reduce the potential for water contamination at mine sites. In general, old abandoned mine sites have a higher potential to pollute nearby waterways because the water control techniques that modern environmental regulations now require were not in place when the mine was opened or closed. Knowledge of water management and impact reduction has greatly increased over time, and the prevention of water contamination is now an important component of mine operation and closure plans.
- **The hydrogeological setting** can also influence the mine-drainage contamination of ground water. In northern West Virginia, shallow ground water (such as that in springs and dug wells) is more susceptible to pollution than deeper ground water. Springs near surface mines typically have lower pH, higher acidity and higher sulphate content than drilled wells near surface mines. Furthermore, properly constructed drilled wells with casings over 30 feet deep usually have little or no problem with mine drainage pollution, even near surface mines.

Preventive and Corrective Measures for Mine Drainage Pollution

Several actions can be taken to lessen the chances of ground-water pollution occurring because of surface mining:

1. Ground water should be directed away from the mine site both during and after mining, where possible. This objective should be easier to achieve for contour mines than for area mines. In contour mines, drainage pipes can be installed in ditches dug at the foot of the high walls just prior to reclamation. This will result in lower water tables after reclamation, and less ground-water contact with fill material.
2. Ground-water drainage could then be directed in pipes towards a nearby stream channel.
3. Another approach would be to install an impermeable barrier in the backfill material, a few feet below the surface. This would have the effect of directing infiltrating rainfall downslope away from the mine and buried toxic overburden.
4. Where possible, surface mining should be kept at least 200 feet away from any well or spring water supply, especially those supplies located downhill from the mine.

5. Also, all bore holes created by coring operations and all old abandoned wells should be filled with concrete grout at the mine site during mining. Otherwise, polluted mine drainage may recharge aquifers underlying the mine.
6. Likewise, wells drilled near the mine to monitor ground water should be grouted following mine reclamation.

Certain Corrective Measures Can Be Taken after Ground-Water Pollution is detected

1. One should first locate and stop discharges from specific pollution sources on the surface mine site, if possible, before reclamation is completed. This could include channelling mine surface water into treatment ponds that are lined with impermeable bottoms.
2. Second, new water supplies should be located for persons whose wells or springs have become polluted. The most dependable water supply would be piped water from a water service district. If piped water is too far away to be economically feasible, then the choices would be a new well, a cistern or a nearby spring.
   (a) It should be located as far away from the mine as possible and away from other potential pollution sources such as septic tanks, acid streams and other mines.
   (b) It should also be properly constructed and sealed, and have enough casing to seal off the upper shallow ground-water zone.
   (c) If possible, a deeper aquifer with potable ground water should be tapped for a water supply.
3. New well drilling and construction should be handled by an experienced water-well driller.

3.3 EFFECT OF POLLUTED WATER ON LIVING ORGANISMS

Freshwater resources all over the world are threatened not only by over exploitation and poor management but also by ecological degradation. The main source of freshwater pollution can be attributed to discharge of untreated waste, dumping of industrial effluent, and run-off from agricultural fields. They not only affect the health of human beings but also have an adverse impact on both animals and trees.

3.3.1 Effect on Human Health

There are a lot of diseases which can be categorised in 3 groups based on the cause of that disease.

(a) Waterborne diseases caused by polluted drinking water:

i) Typhoid

Typhoid fever, also known simply as typhoid, is a common worldwide bacterial disease transmitted by the ingestion of food or water contaminated with the faeces of an infected person, which contain the bacterium Salmonella enterica enterica, serovar Typhi.

The disease has received various names, such as gastric fever, abdominal typhus, infantile remittent fever, slow fever, nervous fever and pathogenic fever. The name typhoid means "resembling typhus" and comes from the neuropsychiatric symptoms common to typhoid and typhus. Despite this similarity of their names, typhoid fever and typhus are distinct diseases and are caused by different species of bacteria.

ii) Amoebiasis

A gastrointestinal infection that may or may not be symptomatic and can remain latent in an infected person for several years, amoebiasis is estimated to cause 70,000 deaths per year world-wide. Symptoms can range from mild diarrhoea to dysentery with blood and mucus in the stool. When no symptoms are present, the infected individual is still a carrier, able to spread the parasite to others through poor hygienic practices.

iii) Giardiasis

Giardiasis (popularly known as **beaver fever**) is a parasitic disease caused by the flagellate protozoan *Giardia lamblia*. It is a common cause of gastroenteritis in humans, infecting approximately 200 million people worldwide. Symptoms include loss of appetite, diarrhoea, haematuria (blood in urine), loose or watery stool, stomach cramps, upset stomach, projectile vomiting (uncommon), bloating, excessive gas, and burping (often sulphurous). Symptoms typically begin one to two weeks after infection and may wane and reappear cyclically.

iv) Ascariasis

Ascariasis is a disease caused by the parasitic roundworm *Ascaris lumbricoides*. Infections have no symptoms in more than 85% of cases, especially if the number of worms is small. Symptoms increase with the number of worms present and may include shortness of breath and fever in the beginning of the disease. These may be followed by symptoms of abdominal swelling, abdominal pain and diarrhoea. Children are most commonly affected and in this age group the infection may also cause poor weight gain, malnutrition and learning problems.

v) Hookworm

Hookworm is a parasitic nematode that lives in the small intestine of its host, which may be a mammal such as a dog, cat, or human. Hookworm affects about 576 million people globally. It is a leading cause of maternal and child morbidity in the developing countries of the tropics and subtropics. In susceptible children hookworms cause intellectual, cognitive and growth retardation, intrauterine growth retardation, prematurity, and low birth weight among new-borns born to infected mothers. In developed countries, hookworm infection is rarely fatal, but anaemia can be significant in a heavily infected individual.

(b) Waterborne diseases caused by polluted beach water

i) Rashes, ear ache, pink eye
ii) Respiratory infections
iii) Hepatitis, encephalitis, gastroenteritis, diarrhoea, vomiting, and stomach aches

(c) Conditions related to water polluted by chemicals (persistent organic pollutants, heavy metals etc.)

i) Cancer including prostate cancer and non-Hodgkin's lymphoma
ii) Hormonal problems that can disrupt reproductive and developmental processes
iii) Damage to the nervous system
iv) Liver and kidney damage
v) Damage to the DNA
vi) Exposure to mercury (heavy metal):

• *In the womb:* may cause neurological problems including slower reflexes, learning deficits, delayed or incomplete mental development, autism and brain damage

• *In adults:* Parkinson's disease, multiple sclerosis, Alzheimer's disease, heart disease, and even death

(d) Other effects

i) Water pollution may also result from interactions between water and contaminated soil, as well as from deposition of air contaminants (such as acid rain)

ii) Damage to people may be caused by fish foods coming from polluted water (a well-known example is high mercury levels in fish)

iii) Damage to people may be caused by vegetable crops grown / washed with polluted water

3.3.2 Effect on Animals

(a) ***Nutrient pollution*** (nitrogen, phosphates etc) causes overgrowth of toxic algae eaten by other aquatic animals, and may cause death; nutrient pollution can also cause outbreaks of fish diseases.

(b) ***Chemical contamination*** can cause declines in frog biodiversity and tadpole mass

(c) ***Oil pollution*** (as part of chemical contamination) can negatively affect development of marine organisms, increase susceptibility to disease and affect reproductive processes; can also cause gastrointestinal irritation, liver and kidney damage, and damage to the nervous system

(d) ***Mercury*** in water can cause abnormal behaviour, slower growth and development, reduced reproduction, and death

(e) ***Persistent organic pollutants*** (POPs) may cause declines, deformities and death of fish life

(f) Too much ***sodium chloride*** (ordinary salt) in water may kill animals

(g) Some higher forms of ***non-aquatic animals*** may also have similar effects from water pollution as those experienced by humans.

3.3.3 Effect on Trees & Plants

(a) May disrupt photosynthesis in aquatic plants and thus affecting ecosystems that depend on these plants

(b) Terrestrial and aquatic plants may absorb pollutants from water (as their main nutrient source) and pass them up the food chain to consumer animals and humans

(c) Plants may be killed by too much sodium chloride (ordinary slat) in water

(d) Plants may be killed by mud from construction sites as well as bits of wood and leaves, clay and other similar materials

(e) Plants may be killed by herbicides in water; herbicides are chemicals which are most harmful to plants.

CHAPTER-4

SAMPLING

4. SAMPLING

4.1 COLLECTION AND PRESERVATION OF SAMPLES

The objective of sampling is to collect representative sample. Representative sample should be such that where relative proportions or concentration of all pertinent components will be the same as in the material being sampled. Moreover, the same sample shall be handled in such a way that no significant changes in composition occur before the tests are made. Again the sample volume should be optimal so as to carry it easily anywhere.

In view of the expanding set on checking the accuracy and representatives of data, more stupendous attention is set on legitimate sample collection, tracking, and conservation procedures. Some consultation is required which is essential to guarantee selecting specimens and systematic systems that give a sound and legitimate premise for observing the queries that incited the inspecting and that will meet administrative and/or task-particular necessities.

4.2 GENERAL REQUIREMENTS OF SAMPLING

- Obtain a sample that meets the requirements of the sampling program and handle it so that it does not deteriorate or become contaminated before it is analyzed.
- Ensure that all sampling equipment is clean and quality-assured before use. Sample containers that are clean and free of contaminants are used.
- Sample containers are filled without pre-rinsing with sample; pre-rinsing results in loss of any pre-added preservative and sometimes can bias results high when certain components adhere to the sides of the container. Depending on determinations to be performed, the container is filled full (most organic compound determinations) or some space is left for aeration, mixing, etc. (microbiological and inorganic analyses).
- Special precautions (discussed below) are necessary for samples containing organic compounds and trace metals. Since many constituents may be present at low concentrations (micro-grams or nano-grams per liter), they may be totally or partially lost or easily contaminated when proper sampling and preservation procedures are not followed.

- Composite samples can be obtained by collecting over a period of time, or at many different over a period of time, depth, or at many different sampling points. The details of collection vary with local conditions, so specific recommendations are not universally applicable.
- For metals it often is appropriate to collect both a filtered and an unfiltered sample to differentiate between total and dissolved metals present in the matrix. Be aware that some metals may partially sorb to filters. Beforehand, determine the acid requirements to bring the pH to <2 on a separate sample. Add the same relative amount of acid to all samples; use ultrapure acid preservative to prevent contamination. When filtered samples are to be collected, filter them, if possible, in the field, or at the point of collection before preservation with acid.
- Record of sample shall be as follows:

1. ***General Information***

    • Sample identification number

    • Location

    • Sample collector

    • Date and hour

    • Sample type (Grab or composite)

2. ***Specific Information***

    • Water temperature

    • Weather

    • Stream blow

    • Water level

    • Any other information

- Rivers, streams, lakes, and reservoirs are subject to considerable variations from normal causes such as seasonal stratification, diurnal variations, rainfall, runoff, and wind. The location, depth, and frequency of sampling is chosen depending on local conditions and

the purpose of the investigation. Areas of excessive turbulence are avoided because of potential loss of volatile constituents and of potential presence of denser-than-air-toxic vapors.

4.3 TYPES OF SAMPLES

a. Grab samples: *A single sample collected at a particular time and place that represents the composition of the water, air, or soil only at that time and place.* Grab samples are single collected at a specific spot at a site over a short period of time (typically seconds or minutes). Thus, they represent a "snapshot" in both space and time of a sampling area. Discrete grab samples are taken at a selected location, depth, and time. Depth-integrated grab samples are collected over a predetermined part of the entire depth of a water column, at a selected location and time in a given body of water.

When a source is known to vary with time, grab samples collected at suitable intervals and analyzed separately can document the extent, frequency, and duration of these variations.

b. Composite samples: *A mixture of a number of single or "grab" samples, intended to produce a typical or average sample may be made up of equal volumes of individual samples, or of single samples proportioned to variations in flow or usage.* Composite samples should provide a more representative sampling of heterogeneous matrices in which the concentration of the analytes of interest may vary over short periods of time and/or space. Composite samples can be obtained by combining portions of multiple grab samples or by using specially designed automatic sampling devices.

Points of interest of composite samples incorporate diminished expenses of investigating countless, more illustrative samples of heterogeneous networks, and bigger specimen sizes when measures of test specimens are constrained. Drawbacks of composite samples incorporate misfortune of analyte connections in distinct samples, potential weakening of analytes beneath identification levels, expanded potential systematic impedances, and expanded probability of analyte cooperations. Moreover, utilization of composite samples may lessen the amount of examples broke down beneath the obliged measurable requirement for specified information quality goals or task particular targets.

4.4 SAMPLING METHODS

a. ***Manual sampling:*** Manual sampling involves minimal equipment but may be unduly costly and time-consuming for routine or large-scale sampling programs. It requires trained field technicians and is often necessary for regulatory and research investigations for which critical appraisal of field conditions and complex sample collection techniques are essential. Manually collect certain samples, such as waters containing oil and grease.

b. ***Automatic sampling:*** Automatic samplers can eliminate human errors in manual sampling, can reduce labor costs, may provide the means for more frequent sampling,3 and are used increasingly. Be sure that the automatic sampler does not contaminate the sample. For example, plastic components may be incompatible with certain organic compounds that are soluble in the plastic parts or that can contaminated (e.g., from phthalate esters) by contact with them. If sample constituents are generally known, contact the manufacturer of an automatic sampler regarding potential incompatibility of plastic components.

4.5 SAMPLE COLLECTION

All the samples are being collected from mining areas of Koira region of Sundargarh district. Both ground-water and surface-water samples are collected to assess the pollution effieciency of both type of samples. For each sample, two 1-litre bottles are used.

Table-4.1: Details of Water Samples collected

Sample No.	Place from where sample is taken
S-1	Nallah near an iron-ore mine in Koida region
S-2	Another Nallah
S-3	Mine Water
S-4	Ground Water Sample near iron-ore mine
S-5	Ground Water Sample-2
S-6	Bore-Well Water Sample
S-7	Nallah very close to an iron-ore mine
S-8	Ground Water of an iron-ore mine

Fig-4.1: Location of Sample-1

Fig-4.2: Location of Sample-2

Fig-4.3: Location of Sample-3

Fig-4.4: Location of Sample-4

Fig-4.5: Location of Sample-6

CHAPTER-5

WATER QUALITY ANALYSIS AND MODELLING

5. WATER QUALITY ANALYSIS AND MODELLING

5.1 WATER QUALITY ANALYSIS

Water is essential to human life and the health of the environment. As a valuable natural resource, it comprises marine, estuarine, freshwater (river and lakes) and groundwater environments that stretch across coastal and inland areas. Water has two dimensions that are closely linked: quantity and quality. **Water quality** is commonly defined by its physical, chemical, biological and aesthetic characteristics. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. A healthy environment is one in which the water quality supports a rich and varied community of organisms and protects public health. Many of our own uses depend on water quality that is suitable for irrigation, watering stock, drinking, fishing and recreation, and to meet cultural and spiritual needs. Even water quality is fundamental for good river health. Water quality sustains ecological processes that support native fish populations, vegetation, wetlands and birdlife.

It is essential to measure water quality periodically because it is not only used for our domestic uses as farming, fishing etc. but also for drinking purpose of both human beings and other living organisms. If water quality is not maintained, it is not just the environment that will suffer - the commercial and recreational value of our water resources will also diminish.

For measurement of water quality, we need to analyse the physical and chemical parameters of water samples.

5.1.1 PHYSICAL PARAMETERS:

The physical parameters include:

1. Colour
2. Turbidity
3. Conductivity
4. Solids
5. Odour

6. Temperature

Turbidity:

It refers to the cloudiness of a solution. It often indicate the presence of dispersed and suspended solids like clay, silt, algae, organic matter etc. It is expressed in Nephelometer Turbidity Unit (NTU).

Apparatus Required:

Turbidity Meter, Sample cells, Standard Flasks, Funnel, Wash Bottle, Tissue

Chemicals Required:

Hexamethylene tetramine, Hydrazine Sulphate, Distilled water

Procedure:

- At first 400 NTU soln is prepared and the turbidity meter is calibrated using standard solution by adjusting the knob.
- Similarly the meter is calibrated to 0 NTU using distilled water.
- Now the sample is inserted and reading is recorded.

Conductivity:

It is defined as the ability to conduct or transmit heat, electricity or sound. It is expressed in mS/cm or mS/m.

Environmental Significance:

- It is useful to assess the source of pollution.
- In coastal regions, it can be used to decide the extent of intrusion of sea water into ground water.
- It is also used indirectly to find out inorganic dissolved salts.

Apparatus Required:

Conductivity meter, Magnetic stirrer, Standard flask, Measuring Jar, Beaker 250 ml, Funnel, Tissue

Chemicals Required:

KCl, Distilled Water

Procedure:

- 0.1 N KCl sol^{n} is prepared.
- Then the conductivity meter is calibrated to 14.12 mho using the standard soln of 0.1N KCl by adjusting the knob.
- Then the electrode is inserted in the sample and conductivity is recorded.

Solids:

The term 'solid' refers to the matter either filterable or non-filterable that remains as residue upon evaporation and subsequent drying at a defined temperature. Water with high dissolved solids results in unfavourable physiological reaction in the consumer. It is also unsuitable for many industrial applications. High suspended solids in waters may be aesthetically unsatisfactory. Analysis of total solids is important to decide upon the various unit operations and processes in physical and biological wastewater treatment.

Principle:

Residue left after the evaporation and subsequent drying in oven at specific temperature 103-105°C of a known volume of sample are total solids. Total solids include "Total suspended solids" (TSS) and "Total dissolved solids" (TDS). Whereas loss in weight on ignition of the same sample at 500°C, 50°C, in which organic matter is converted to CO2 volatilisation of inorganic matter as much as consistent with complete oxidation of organic matter, are volatile solids.

Apparatus:

1. Electrically heated temperature controlled oven

2. Mono-pan balance

3. Evaporating dish (200mL)

4. Pipettes

5. Measuring cylinder (100mL)

Procedure:

1. A known volume of a well-mixed sample is taken in a tarred dish ignited to constant weight (W1)

2. The sample is evaporated to dryness at 103-105°C for 24hrs.

3. Then it is cooled in desiccators, weighed and the reading is recorded. (W2)

4. The concentration is calculated in percent by weight.

Calculation:

The total solids is expressed as:

Total solids, mg/L = (W2 - W1) x 1000 / mL of sample

Total dissolved solids:

It is the filterable residue is the material that passes through a standard glass filter disk and remains after evaporation and drying at 180°C.

Environmental Significance:

- Dissolved minerals, gases and organic constituents produce displeasing colour, taste and odour.
- Some dissolved solids may deplete the dissolved oxygen in water.
- Some are identified also as carcinogenic in nature.
- Use of water with high amount of dissolved solids in industries may lead to corrosion and degraded quality of product.

Procedure

1. The well-mixed sample is filtered under vacuum through membrane filter or Gooch Crucible.

2. 100mL or more filtrate is taken in a weighed evaporating dish.

3. Then it is evaporated to dryness on steam bath for at least 1 hour in an oven at 180±2°C and is cooled in a desiccator and weighed.

Calculation:

Total filterable residue at 180°C = (A –B) x 1000 / C

Where:

A = weight of dried residue + dish

B = weight of dish

C = mL of filtrate used

Total suspended solids

It is found out by subtracting the total dissolved solids from the total solids. It can be referred to materials which are not dissolved in water and are non-filterable in nature.

Environmental Significance:

- Suspended materials is aesthetically not pleasing and also releases obnoxious odour sometimes.
- It is also used to measure the quality of waste water influent and effluent.
- These materials exclude light thus reducing the growth of oxygen producing plants.

The results of the physical parameters obtained by following the above procedure is presented in the following table.

Table-5.1: Results of Physical Parameters of the Samples

Sample No.	Temperature (^{0}C)	Conductivity (mS/cm)	Turbidity (NTU)	TDS (mg/L)
S-1	29.7	0.158	51	0.103
S-2	29.13	0.097	29	0.063
S-3	32.3	0.036	58.9	0.024
S-4	28.9	0.121	13.1	0.079
S-5	28.74	0.100	59.5	0.065
S-6	31.61	0.037	5.3	0.024
S-7	27.28	0.102	25.6	0.066
S-8	28.04	0.295	13.4	0.192

5.1.2 CHEMICAL PARAMETERS:

The chemical parameters include:

1. pH
2. Hardness
3. Nitrate
4. Sulphate
5. Fluoride
6. Chloride
7. Phosphate
8. DO (Dissolved Oxygen)
9. BOD (Bio-chemical Oxygen Demand)

pH:

$pH = -\log[H^+]$

If pH < 7, the solution is acidic

If pH > 7, then it is basic and

if pH = 7, the solution is neutral.

Environmental Significance:

Determination of pH is one of the important objectives in biological treatment of the waste water. In anaerobic treatment, if the pH goes below 5, the process is affected. Chemical Coagulation, Disinfection, Water Softening and Corrosion control are governed by pH adjustments.

Apparatus required:

1. pH meter
2. Reference electrode
3. Sensor electrode
4. Beaker
5. Stirrer

Chemicals required:

1. pH 4 buffer
2. pH 7 buffer
3. pH 10 buffer
4. KCl
5. Distilled water

Calibration:

Before use, remove the electrodes from the water and rinse with distilled or demineralised water. Dry the electrodes by gentle wiping with a soft tissue. Calibrate the electrode system against standard buffer solution of known pH. Because buffer solution may deteriorate as a result of mould growth or contamination, prepare fresh as needed for work or use readily available pH buffers. Use distilled water a conductivity of less than 2μ Siemens at 25°C and distilled and pH 5.6 to 6.0 for the preparation of all standard solutions. For routine analysis, commercially available buffer tablets, powders or solutions of tested quality also are permissible. Buffer having pH 4.0, 7.0 and 9.2 are available. In preparing buffer solutions from solid salts, dissolve all the material; otherwise, the pH calibration will be incorrect. Prepare and calibrate the electrode system with buffer solutions with pH approximating that of the sample, to minimise error resulting from nonlinear response of the electrode.

Procedure:

1. The electrodes are removed from storage solutions (recommended by manufacturer) and rinse with distilled water.

2. Electrodes are dried by gently blotting with a soft tissue paper, and are standardised using a buffer solution within 2 pH units of sample pH.

3. Calibrate the pH meter to 10, 7 and 4 successively using the corresponding buffer solutions.

4. Then the sample is inserted and the pH is recorded.

Hardness:

It is the property of water by virtue of which the amount of mineral content can be known. Hard water contains bicarbonate, chlorides and sulphates of calcium and magnesium.

Environmental Significance:

- Soft waters are corrosive and dissolve the metals.
- Cardio-Vascular diseases are reported in soft-water areas.
- Hard water is useful in the growth of children.
- Excessive soap is consumed in case of hard-water for cleaning.

Apparatus Required:

1. Burette
2. Pipette
3. Conical Flask
4. 250 ml cylinder
5. Standard Flask
6. Beaker

Chemicals Required:

1. NH_4Cl
2. NH_4OH
3. EDTA
4. Erichrome Black T(EBT) Indicator
5. $MgSO_4$

Procedure:

- 20 ml of sample is pipetted out and 2 ml of Ammonia buffer is added to it.
- 2 drops of EBT is added and solution turns red-wine.
- Titration is done with EDTA solution till the red wine soln turns steel blue.
- Hardness is then calculated as:

$$\textbf{Ca Hardness} = \frac{(Vol.\ of\ EDTA) * N * (Equivalent\ Wt. of\ CaCO3) * 1000}{Vol.\ of\ Sample\ taken}$$

where N = Normality of EDTA

Nitrate:

Nitrate is the highest oxidised form of nitrogen compounds that are present in natural waters. Chemical fertilizers, decayed vegetable and animal matter, domestic effluents, sewage sludge disposal to land, industrial discharge, leachates from refuse dumps and atmospheric washout are the significant sources of nitrate.

Though it can occur in all kinds of water bodies but it concentration may go higher in areas near coal mines due to their organic origin.

Principle:

Nitrate reacts with Phenol disulphonic acid and produces a nitro-derivative which in alkaline solution develops yellow colour due to rearrangement of its structure. The colour produced follows Beer's law and is intensity proportional to the concentration of NO3 present in the sample.

Apparatus:

1. Colorimetric or spectrophotometer having a range of 300-700nm.

2. Nessler tubes, capacity, 100mL.

3. Beakers, capacity, 100mL.

4. Water bath

Reagents:

1. Standard silver sulphate (1ml=1mg)

2. Phenol disulfonic acid (PDA)

3. Ammonium hydroxide NH4OH conc

4. Potassium hydroxide, 12N

5. Standard nitrate solution (1ml=10 μg N)

6. EDTA reagent

7. Aluminium hydroxide

Procedure:

1. The colorimeter is calibrated using standard nitrate solution and calibration curve (absorbance Vs. Concentration) is plotted.
2. The sample is neutralised to pH 7.0.
3. Suitable aliquot of the sample is taken in a beaker and evaporated to dryness on water bath.
4. The residue is dissolved using glass rod with 2mL phenol disulphonic acid reagent. Then is diluted and transferred to Nessler's tubes.
5. 8-10mL 12N KOH is added.

6. If turbidity develops the EDTA reagent is added drop-wise till it dissolves.
7. The solution is filtered and made up to 100mL. To avoid turbidity 10mL conc. NH4OH is added instead of KOH.
8. Blank is prepared in the same way using distilled water in place of sample.
9. Then the sample is subjected to colorimetry and the intensity of colour developed at 410nm with a light path of 1cm is read.

Calculation:

The concentration of Nitrate is calculated from the standard calibration curve and the values are reported in mg/L.

Sulphate:

Sulphate ions usually occur in natural waters. Many sulphate compounds are readily soluble in water. Most of them originate form the oxidation of sulphate ores, the solution of gypsum and anhydrite, the presence of shales, particularly those rich in organic compounds, and the existence of industrial wastes. Atmospheric sulphur dioxide formed by the combustion of fossil fuels and emitted by the metallurgical roasting processes may also contribute to the sulphate compounds of water. Sulphur trioxide (SO_3) produces by the photolytic oxidation of sulphur dioxide comes with water vapours to form sulphuric acid which is precipitated as acid rain or snow.

Environmental Significance:

- They are indirectly responsible for serious problems associated with the handling and treatment of waste water.
- The amount of sulphates in waste water is a factor of concern in determining the magnitude of problems that can arise from reduction of sulphates to hydrogen sulphide.

Turbidimetric method (Principle):

This method is used for the determination of sulphate ions. Sulphate ion (SO_4^{--}) is precipitated in an acetic acid medium with Barium chloride ($BaCl_2$) so as to form Barium sulphate ($BaSO_4$) crystals of uniform size. The reaction involved is given below:

$Ba^{++} + SO_4$— $BaSO_4$ (White suspension)

Light absorbance of the $BaSO_4$ suspension is measured by a photometer or the scattering of light by Nephelometer.

Apparatus Required:

a. Magnetic stirrer

b. Colorimeter for use at 420mm or turbidimeter/nephelometer

c. Stopwatch

d. Nessler tubes, 100mL

e. Measuring spoon 0.2 to 0.3mL

Chemicals Required:

a. Buffer solution A: dissolve 30g Magnesium chloride, $MgCl_2.6H_2O$, 5g Sodium acetate $CH_3COONa.3H_2O$, 1g Potassium nitrate, KNO_3 and 20mL acetic acid, CH_3COOH (99%) in 500mL distilled water and make up to 1000mL.

b. Buffer solution B: (required when the sample sulphate (SO_4^{--}) is less than 10mg/L). Dissolve 30g Magnesium chloride, $MgCl_2.6H_2O$, 5g sodium acetate, $CH_3COONa.3H_2O$, 1.0g of potassium nitrate, KNO_3, 0.111 g of sodium sulphate, Na_2SO_4 and 20mL acetic acid (99%) in 500mL distilled water an make up to 1000mL.

c. Barium chloride: crystals, 20-30mesh.

d. Standard sulphate solution: dissolve 0.1479g anhydrous sodium sulphate, Na_2SO_4 in distilled water and dilute to 1000mL. 1L = 100 μg SO_4^{--}

Procedure:

- Take suitable volume of sample and dilute to 100mL into a 250mL Erlenmeyer flask
- Add 20mL buffer solution, mix well
- Keep the flask constantly stirred with the help of stirrer. Add 1-spatula $BaCl_2$ crystals with stirring. Continue stirring for 1 minute after addition of $BaCl_2$
- Pour suspension into an absorption cell of photometer an measure turbidity at 5±0.5 min
- To correct for sample colour and turbidity, run a blank to which $BaCl_2$ is not added.

Calculation:

mg SO4--/L = {mg (SO_4^{--}) x 1000} / {mL of sample}

Fluoride:

Fluoride ions have dual significant in water supplies. High concentration of F^- causes dental fluorosis (disfiguerment of the teeth). At the same time, a concentration less than 0.8mg/L results in 'dental caries'. Hence, it is essential to maintain the F^- concentration between 0.8 to 1.0mg/L in drinking water.

Ion Selective Electrode Method (Principle):

When the fluoride electrode is dipped in sample whose concentration is to be measured, a potential is established by the presence of fluoride ions by any modern pH meter having an expanded millivolt scale. Thus we can find the conc. by measuring the potential developed.

Apparatus Required:

1. Ion meter (field/laboratory mode) or pH/mV meter
2. Reference electrode (calomel electrode)
3. Fluoride-sensitive electrodes
4. Magnetic stirrer
5. Plastic lab ware

Chemicals Required:

1. Standard fluoride solution
2. Total Ionic Strength Adjustment Buffer (TISAB)

Procedure:

1. The electrode is calibrated using the standard fluoride solution.
2. Connection of the electrodes to meter and for further operations of the instrument is done as per the instruction manual.

3. The electrode slope is checked with the ion meter (59.16mV for monovalent ions and 29.58mV for divalent ions at 25°C).

4. 50 to 100mL of sample is taken in a 150mL plastic beaker. TISAB is added.

5. Electrode is rinsed, blotted dry and placed in the sample. Stirring is done thoroughly and the steady reading on the meter is noted.

6. Recalibration is done in every 1 hour.

Calculation:

The concentration in mg/L is obtained directly from the specific ion meter.

Phosphate:

Various forms of Phosphates get into water source mainly via waste water from residential area or from fertiliser and cleaning industry. The presence of phosphate in large quantities in fresh waters indicates pollution through sewage and industrial wastes. It promotes growth of nuisance causing micro-organisms. Though phosphate poses problems in surface waters, its presence is necessary for biological degradation of wastewaters.

Stannous chloride method:

Principle:

In phosphate analysis the phosphorous in any form is tried to convert into orthophosphate form mainly via acid hydrolysis. In acidic condition, orthophosphate reacts with ammonium molybdate to form molybdophosphoric acid. It is further reduced to molybdenum blue by adding reducing agent such as stannous chloride or ascorbic acid. The blue colour developed after addition of ammonium molybdate is measured at 690 or 880nm within 10-12 minutes after development of colour by using blank. The concentration is calculated from the standard graph. The intensity of the blue coloured complex is measured which is directly proportional to the concentration of phosphate present in the sample.

Apparatus:

1. Colorimeter for use at 690nm and 880nm providing 0.5cm light path.

2. Nessler tubes, 100mL

Chemicals:

1. Stock phosphate solution

2. Ammonium molybdate solution

3. Strong acid reagent (concentrated H_2SO_4+ 4ml of HNO_3)

4. Sodium hydroxide 6N

5. Phenolphthalein indicator

6. Stannous chloride reagent I

7. Dilute stannous chloride reagent II

8. Potassium antimonyl tartrate solution

9. Ascorbic acid

10. Combined reagent(combination of the reagents 2, 3, 8, 9)

Procedure:

1. Absorbance vs. Phosphate concentration is plotted for the colorimeter using working phosphate solution and blank solution and so the instrument is calibrated.

2. For Total phosphate: Organically combined phosphorus and all phosphate including polyphosphate as first converted to orthophosphate by digestion as given below.

3. 100mL of well mixed sample is taken in a 150mL conical flask and one drop of phenolphthalein indicator is added. If red colour develops, sulphuric acid solution is added drop wise to just discharge the colour.

4. Then 1mL sulphuric acid solution in excess is added and boiled gently for at least 90 minutes, adding distilled water to keep the volume between 25 and 50mL. One drop of phenolphthalein indicator is added after it cooled and is neutralized to a faint pink colour with hydroxide solution.

5. 50 ml of the solution is taken in colorimetry and then concentration of phosphate is read from calibration curve.

Calculation:

The concentration is found out from the absorbance vs. Concentration plot.

Chloride:

Chlorides are widely distributed as salts of calcium, potassium and sodium in water and waste water. In portable water, the salty taste produced by chloride concentrations is variable and dependent on the chemical composition of water.

Environmental Significance:

- It can corrode concrete and can also create problem in boilers.
- Chloride determination in natural water are useful in the selection of water supplies.
- It is also used to determine the type of desalting apparatus to be used.

Apparatus Required:

1. Burette
2. Pipette
3. Conical Flask
4. Standard Flask
5. Beaker
6. Wash Bottle

Chemicals:

1. $AgNO_3$
2. Phenolpthalein Indicator
3. Sodium Chloride
4. Potassium Chromate

Procedure:

- 20 ml of sample is pipetted out in a 250 ml flask and 2 drops of potassium chromate indicator is dropped in the sample.
- Then titration of the sample is done against silver nitrate solution(0.02 N).
- Titration is done till the yellow colour of sample changes to brick red.
- Chloride concentration is calculated by:

$$Cl^- = \frac{Vol.of\ Silver\ Nitrate * Normality * 35.45 * 1000}{Vol.of\ \ sample\ taken}$$

Dissolved Oxygen (DO):

All living organisms are dependent upon oxygen in one form or the other to maintain the metabolic processes that produce energy for growth and reproduction. Dissolved Oxygen (DO) is also important in precipitation and dissolution of inorganic substances in water.

Environmental Significance:

- It is necessary to know DO levels to assess quality of raw water and to keep a check on stream pollution.
- In wastewaters, dissolved oxygen is the factor that determines whether the biological changes are brought out by aerobic or anaerobic organisms.
- DO test is the basis of BOD test which is an important parameter to evaluate pollution potential of wastes.
- DO is necessary for all aerobic biological wastewater treatment processes.
- Oxygen is an important factor in corrosion. DO test is used to control the amount of oxygen in boiler feed waters either by chemical or physical methods.
- Even drinking water should be rich in DO for good taste.

Apparatus Required:

1. Burette
2. Pipette
3. 300 ml glass stoppered bottles
4. 500 ml conical flask
5. 250 ml cylinder
6. Wash bottle

Chemicals Required:

1. Manganous Sulphate soln
2. Alkaline Iodide-Azide soln
3. Conc. Sulphuric Acid
4. Starch Indicator soln
5. Sodium Thiosulphate
6. Distilled Water
7. Potassium Hydroxide
8. Potassium Iodide

9. Sodium Azide

Procedure:

- First the BOD bottle is filled with sample.
- Then 2 ml of manganous sulphate and 2 ml of alkali iodide-azide reagent is added to the sample by using the pipette dipped inside the sample.
- The contents is mixed and the precipitate is allowed to settle down.
- Again 2 ml of conc. sulphuric acid is added to the sample by a pipette. Then the contents is mixed thoroughly.
- The mouth of the bottle is covered with an aluminium foil and it is stored for 5 hours in a cool dark place.
- Then exactly 203 ml of sample is poured onto a 500 ml conical flask.
- Then the content is titrated against sodium thiosulphate so as to get stray yellow colour and then 2 ml of starch is added to the conical flask to obtain blue colour.
- Then titration is continued until the sample turns colourless.
- Thus the amount of sodium thiosulphate used is measured from which we can calculate the DO.

  Dissolved Oxygen = $$\frac{\boldsymbol{Vol.of\ Sodium\ Thiosulphate * 0.2 * 1000}}{\boldsymbol{Vol.of\ Sample\ taken}}$$

Since 1ml of 0.025N sodium thiosulphate = 0.2 mg of O_2

Bio-chemical Oxygen Demand (BOD):

It is the amount of oxygen required for the biological decomposition of dissolved organic matter to occur under standard condition at std. time and temp. (Time = 5 days; temp = 20^0C)

Significance:

- BOD is the principle test to give an idea of the bio-degradability of any sample and strength of the waste.
- It is an important parameter to assess the pollution of surface water and ground water where contamination is due to domestic and industrial effluents.
- Drinking water has a BOD of less than 1 mg/l but when BOD reaches 5, the water is said to be impure.

- Efficiency of any treatment plant can be judged by considering influent BOD and the effluent BOD and so also the organic loading on the unit.

Principle:

This test measures the oxygen utilised for the biochemical degradation of organic material (carbonaceous demand) and oxidation of inorganic material such as sulphides and ferrous ions during a specified incubation period. It also measures the oxygen used to oxidize reduced forms of nitrogen (nitrogenous demand) unless their oxidation is prevented by an inhibitor. Temperature effects are held constant by performing a test at fixed temperature. The methodology of BOD test is to compute a difference between initial and final Do of the samples incubation. Minimum 1.5 L of sample is required for the test. DO is estimate by iodometric titration.

Apparatus and Chemicals:

1. BOD bottles 300mL capacity
2. Incubator or water-bath to be controlled at 20ºC or at any desired temperature 1ºC.
3. Phosphate buffer
4. Magnesium sulphate
5. Calcium chloride
6. Ferric chloride
7. Sodium sulphate solution 0.025N
8. Acid and Alkali solutions 1N
9. Glucose-glutamic acid solution
10. Nitrification inhibitor
11. Alkali iodide-azide reagent
12. Sulphuric acid
13. Starch indicator
14. Standard sodium thiosulphate (0.025N)

Procedure:

Preparation of dilution water:

1. Distilled water, tap or receiving-stream water free of biodegradable organics and bio-inhibitory substances such as chlorine or heavy metals are used.
2. The required volume of dilution water is aerated in a suitable bottle by bubbling clean-filtered compressed air for sufficient time to attain DO saturation at room temperature or at 20ºC/27ºC.
3. 1mL each of phosphate buffer, magnesium sulphate, calcium chloride and ferric chloride are added to solutions in that order for each Litre of dilution water.
4. For wastes which are not expected to have sufficient microbial population, seed is essential. BOD of the seeding material is determined.

Sample preparation:

1. The sample is neutralised to pH 7, if it is highly acidic or alkaline.
2. The sample is freed from residual chlorine using Na2S2O3 solution.
3. Samples are brought down to 20 ± 1ºC before making dilutions.
4. If nitrification inhibition is desired, 3mg 2-chloro-6-(trichloromethyl) pyridine (TCMP) is added to each 300mL bottle before capping or sufficient amount to the dilution water is added to make a final concentration of 30mg/L.
5. Samples having high DO contents, DO ≥ 9mg/L are treated to reduce the DO content to saturation at 20ºC. The sample is agitated or aerated with clean, filtered compressed air.
6. Dilutions that result in a residual DO of at least 1mg/L and DO uptake of at least 2mg/L produces reliable results. So several dilutions are made to pre-treated sample so as to obtain about 50% depletion of DO or DO uptake of 2mg/L.

Sample processing:

1. The diluted or undiluted sample is siphoned in three labelled bottles and stopper immediately.
2. DO of 1 bottle is determined initially and the other 2 bottles are kept at 20ºC for 3days.

3. The O_2 consumption is measured in dilution water.
4. BOD of seed blank is determined for correction of actual BOD.
5. DO in a BOD test can is determined in the blank on initial day and end of incubation period by Winkler method as described for DO measurement.

Calculations:

BOD of the sample is calculated as follows:

a) When dilution water is not seeded

BOD as O_2 mg/L ={(D1 –D2) x 100}/ % dilution

b) When dilution is seeded

BOD O_2 mg/L = {(D1 – D2) – (B1 –B2) x 100}/ % dilution

Where,

D1 = DO of sample immediately after preparation, mg/L

D2 = DO of sample after incubation period, mg/L

B1 = DO of blank (seeded dilution water) before incubation, mg/L

B2 = DO of blank (seeded dilution water) after incubation, mg/L

The results of the chemical parameters obtained by following the above procedure is presented in the following table.

Table-5.2: Results of Chemical Parameters of samples

Sample No.	pH	Hardness	Nitrate (mg/L)	Sulphate (mg/L)	Chloride (mg/L)	DO (mg/L)	BOD (mg/L)
S 1	7.87	372.7	14.69	29.425	109.07	9.27	2.35
S 2	7.51	212.7	2.72	36.487	57.64	7.91	1.89
S 3	8.25	379.8	12.73	107.10	108.73	7.40	1.16
S 4	6.35	525.6	39.42	150.6	133.26	6.32	0.78
S 5	6.10	540.7	36.39	247.17	135.7	5.97	1.72
S 6	5.74	232.8	3.92	3.531	115.47	6.89	1.09
S 7	6.99	156.2	1.05	15.301	55.23	8.07	1.03
S 8	7.15	178.51	1.14	16.478	51.98	7.59	0.83

5.2 WATER QUALITY MODELLING

Water quality modelling involves the prediction of water pollution using mathematical simulation techniques. A typical water quality model consists of a collection of formulations representing physical mechanisms that determine position and momentum of pollutants in a water body. Models are available for individual components of the hydrological system such as surface runoff; there also exist basin-wide models addressing hydrologic transport and for ocean and estuarine applications. Also contamination of water can be found out by measuring the Water Quality Index (WQI) value.

A water quality index provides a single number that expresses overall water quality at a certain location and time based on several water quality parameters. The objective of an index is to turn complex water quality data into information that is understandable and useable by the public. A lot of WQI Models are present which gives different values considering different parameters as its input. That's why use of WQI is a controversial issue among water quality scientists. However, a water index based on some very important parameters can provide a simple indicator of water quality. It gives the public a general idea the possible problems with the water in the region.

For the modelling of the samples collected, 2 Index is considered here.

5.2.1 WEIGHTED ARITHMETIC WATER QUALITY INDEX(WAWQI) METHOD:

Weighted arithmetic water quality index method classified the water quality according to the degree of purity by using the most commonly measured water quality variables. It considers the following parameters: pH, Conductivity, DO, BOD, TDS, Hardness, Nitrate, Sulphate, and Chloride. The method has been widely used by the various scientists and the calculation of WQI was made by using the following equation:

$$WQI = \sum QiWi / \sum Wi$$

The quality rating scale (Qi) for each parameter is calculated by using this expression:

$$Qi = 100[(Vi - Vo/Si - Vo)]$$

Where,

Vi is estimated concentration of ith parameter in the analysed water

Vo is the ideal value of this parameter in pure water

Vo = 0 (except pH =7.0 and DO = 14.6 mg/l)

Si is recommended standard value of ith parameter

The unit weight (Wi) for each water quality parameter is calculated by using the following formula:

$$Wi = K/Si$$

Where,

K = proportionality constant and can also be calculated by using the following equation:

$$K = \frac{1}{\sum(1/Si)}$$

The rating of water quality according to this WQI **(Brown, 1972)** is:

Table-5.3: WA-WQI Limits

WQI VALUE	RATING OF WATER QUALITY	GRADING
0-25	**Excellent water quality**	**A**
25-50	**Good water quality**	**B**
50-75	**Poor water quality**	**C**
75-100	**Very Poor water quality**	**D**
>100	**Unsuitable for drinking purpose**	**E**

The observation of WQI values of all the samples as per WA-WQI method is presented in the following tables:

Table-5.4: WA-WQI calculation of Sample-1

Parameters	Vo	Si	Vi	Qi	1/Si	Weights (Wi)	Qi * Wi
pH	7	8.5	7.87	58	0.11765	0.21132837	12.25704575
TDS	0	500	103	20.6	0.002	0.00359258	0.074007197
Conductivity	0	400	158	39.5	0.0025	0.00449073	0.177383755
Hardness	0	300	372.7	124.233	0.00333	0.00598764	0.743864139
DO	14.6	5	9.27	55.5208	0.2	0.35925824	19.94631672
BOD	0	5	2.35	47	0.2	0.35925824	16.88513716
Chloride	0	250	109.07	43.628	0.004	0.00718516	0.313474368
Nitrate	0	45	14.69	32.6444	0.02222	0.03991758	1.303087286
Sulphate	0	200	29.425	14.7125	0.005	0.00898146	0.13213967
Total					0.5567		51.83245604
Constant (K)					1.79629		

WQI =51.832

Table-5.5: WA-WQI calculation of Sample-2

Parameters	Vo	Si	Vi	Qi	1/Si	Weights (Wi)	Qi * Wi
pH	7	8.5	7.51	34	0.11765	0.21132837	7.185164748
TDS	0	500	63	12.6	0.002	0.00359258	0.045266538
Conductivity	0	400	97	24.25	0.0025	0.00449073	0.108900153
Hardness	0	300	212.7	70.9	0.00333	0.00598764	0.424523484
DO	14.6	5	7.91	69.6875	0.2	0.35925824	25.03580842
BOD	0	5	1.89	37.8	0.2	0.35925824	13.57996137
Chloride	0	250	57.64	23.056	0.004	0.00718516	0.165661158
Nitrate	0	45	2.72	6.04444	0.02222	0.03991758	0.241279606
Sulphate	0	200	36.487	18.2435	0.005	0.00898146	0.163853191
Total					0.5567		46.95041867
Constant (K)					1.79629		

WQI = 46.95

Table-5.6: WA-WQI calculation of Sample-3

Parameters	Vo	Si	Vi	Qi	1/Si	Weights (Wi)	Qi * Wi
pH	7	8.5	8.25	83.3333	0.11765	0.21132837	17.61069791
TDS	0	500	24	4.8	0.002	0.00359258	0.017244395
Conductivity	0	400	36	9	0.0025	0.00449073	0.040416552
Hardness	0	300	379.8	126.6	0.00333	0.00598764	0.758034881
DO	14.6	5	7.4	75	0.2	0.35925824	26.94436781
BOD	0	5	1.16	23.2	0.2	0.35925824	8.334791108
Chloride	0	250	108.73	43.492	0.004	0.00718516	0.312497185
Nitrate	0	45	12.73	28.2889	0.02222	0.03991758	1.12922404
Sulphate	0	200	107.1	53.55	0.005	0.00898146	0.480956965
Total					0.5567		55.62823084
Constant (K)					1.79629		

WQI = 55.628

Table-5.7: WA-WQI calculation of Sample-4

Parameters	Vo	Si	Vi	Qi	1/Si	Weights (Wi)	Qi * Wi
				-			-
pH	7	8.5	6.35	43.3333	0.11765	0.21132837	9.157562914
TDS	0	500	79	15.8	0.002	0.00359258	0.056762802
Conductivity	0	400	121	30.25	0.0025	0.00449073	0.135844521
Hardness	0	300	525.6	175.2	0.00333	0.00598764	1.049034053
DO	14.6	5	6.32	86.25	0.2	0.35925824	30.98602298
BOD	0	5	0.78	15.6	0.2	0.35925824	5.604428503
Chloride	0	250	133.26	53.304	0.004	0.00718516	0.382998022
Nitrate	0	45	39.42	87.6	0.02222	0.03991758	3.496780177
Sulphate	0	200	150.6	75.3	0.005	0.00898146	0.676303632
Total					0.5567		33.23061177
Constant (K)					1.79629		

WQI = 33.23

Table-5.8: WA-WQI calculation of Sample-5

Parameters	Vo	Si	Vi	Qi	1/Si	Weights (Wi)	Qi * Wi
pH	7	8.5	6.1	-60	0.11765	0.21132837	-12.6797025
TDS	0	500	65	13	0.002	0.00359258	0.046703571
Conductivity	0	400	100	25	0.0025	0.00449073	0.112268199
Hardness	0	300	540.7	180.233	0.00333	0.00598764	1.079171828
DO	14.6	5	5.97	89.8958	0.2	0.35925824	32.29581863
BOD	0	5	1.72	34.4	0.2	0.35925824	12.35848337
Chloride	0	250	135.7	54.28	0.004	0.00718516	0.390010743
Nitrate	0	45	36.39	80.8667	0.02222	0.03991758	3.228001792
Sulphate	0	200	247.17	123.585	0.005	0.00898146	1.109973232
Total					0.5567		37.94072887
Constant (K)					1.79629		

WQI = 37.94

Table-5.9: WA-WQI calculation of Sample-6

Parameters	Vo	Si	Vi	Qi	1/Si	Weights (Wi)	Qi * Wi
pH	7	8.5	5.74	-84	0.11765	0.21132837	-17.7515835
TDS	0	500	24	4.8	0.002	0.00359258	0.017244395
Conductivity	0	400	37	9.25	0.0025	0.00449073	0.041539234
Hardness	0	300	232.8	77.6	0.00333	0.00598764	0.464640654
DO	14.6	5	6.89	80.3125	0.2	0.35925824	28.85292719
BOD	0	5	1.09	21.8	0.2	0.35925824	7.831829575
Chloride	0	250	115.47	46.188	0.004	0.00718516	0.331868389
Nitrate	0	45	3.92	8.71111	0.02222	0.03991758	0.347726492
Sulphate	0	200	3.531	1.7655	0.005	0.00898146	0.01585676
Total					0.5567		20.1520492
Constant (K)					1.79629		

WQI = 20.15

Table-5.10: WA-WQI calculation of Sample-7

Parameters	Vo	Si	Vi	Qi	1/Si	Weights (Wi)	Qi * Wi
				-			-
pH	7	8.5	6.99	0.66667	0.11765	0.21132837	0.140885583
TDS	0	500	66	13.2	0.002	0.00359258	0.047422087
Conductivity	0	400	102	25.5	0.0025	0.00449073	0.114513563
Hardness	0	300	156.2	52.0667	0.00333	0.00598764	0.311756315
DO	14.6	5	8.07	68.0208	0.2	0.35925824	24.43704469
BOD	0	5	1.03	20.6	0.2	0.35925824	7.40071969
Chloride	0	250	55.23	22.092	0.004	0.00718516	0.15873466
Nitrate	0	45	1.05	2.33333	0.02222	0.03991758	0.093141025
Sulphate	0	200	15.301	7.6505	0.005	0.00898146	0.068712629
Total					0.5567		32.49115908
Constant (K)					1.79629		

WQI = 32.49

Table-5.11: WA-WQI calculation of Sample-8

Parameters	Vo	Si	Vi	Qi	1/Si	Weights (Wi)	Qi * Wi
pH	7	8.5	7.15	10	0.11765	0.21132837	2.113283749
TDS	0	500	192	38.4	0.002	0.00359258	0.137955163
Conductivity	0	400	295	73.75	0.0025	0.00449073	0.331191188
Hardness	0	300	178.51	59.5033	0.00333	0.00598764	0.356284378
DO	14.6	5	7.59	73.0208	0.2	0.35925824	26.23333588
BOD	0	5	0.83	16.6	0.2	0.35925824	5.963686741
Chloride	0	250	51.98	20.792	0.004	0.00718516	0.149393945
Nitrate	0	45	1.14	2.53333	0.02222	0.03991758	0.101124541
Sulphate	0	200	16.478	8.239	0.005	0.00898146	0.073998215
Total					0.5567		35.4602538
Constant (K)					1.79629		

5.2.2 NATIONAL SANITATION FOUNDATION WATER QUALITY INDEX (NSF-WQI)

Eight water quality parameters were selected to include in the index. These parameters are:

- dissolved oxygen (DO)
- fecal coliform
- pH
- biochemical oxygen demand (BOD) (5-day)
- temperature change (from 1 mile upstream)
- nitrate
- turbidity
- total dissolved solids

First the eight parameters are measured and then its corresponding Quality value is estimated from the graph.

$$\text{NSF WQI} = \frac{\sum \boldsymbol{QW}}{\sum \boldsymbol{W}}$$

Where Q = quality value of a parameter

And W = weight of that parameter.

The WQI ranges have been defined as **(Brown and others, 1970)**:

Table-5.12: NSF WQI Limits

WQI	RATING OF WATER QUALITY
90-100	**Excellent**
70-90	**Good**
50-70	**Medium**
25-50	**Bad**
0-25	**Very Bad**

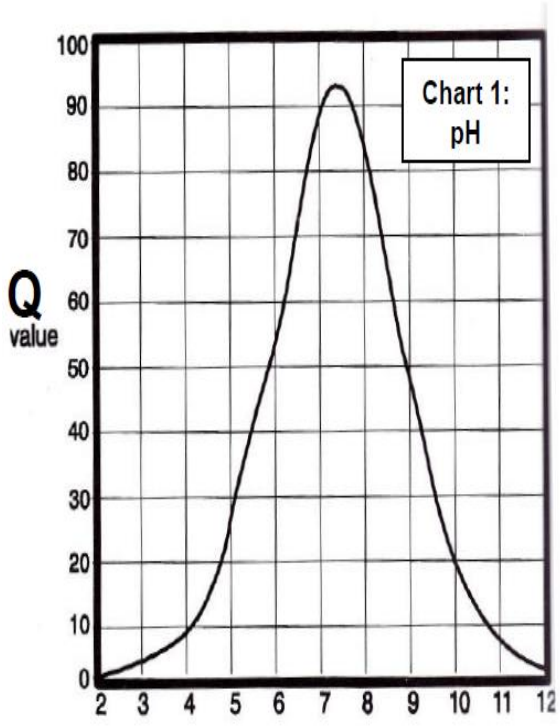

Fig-5.1 (Q-value for pH)

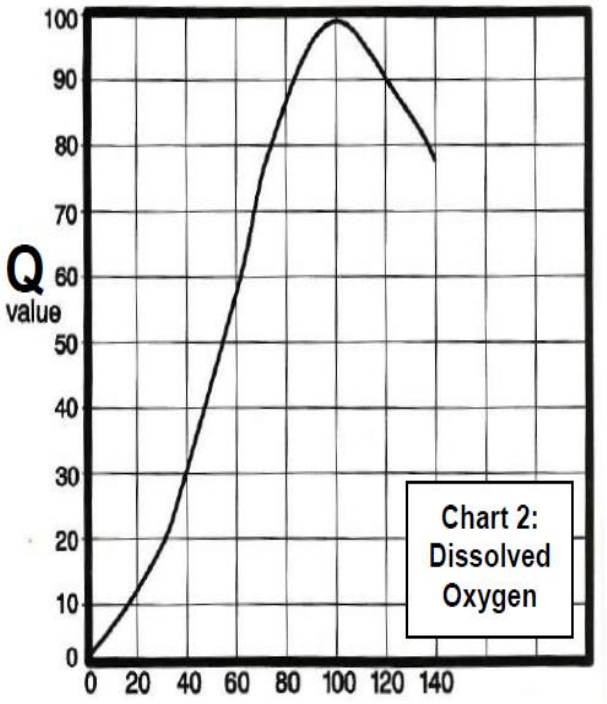

Fig-5.2 (Q-value for DO)

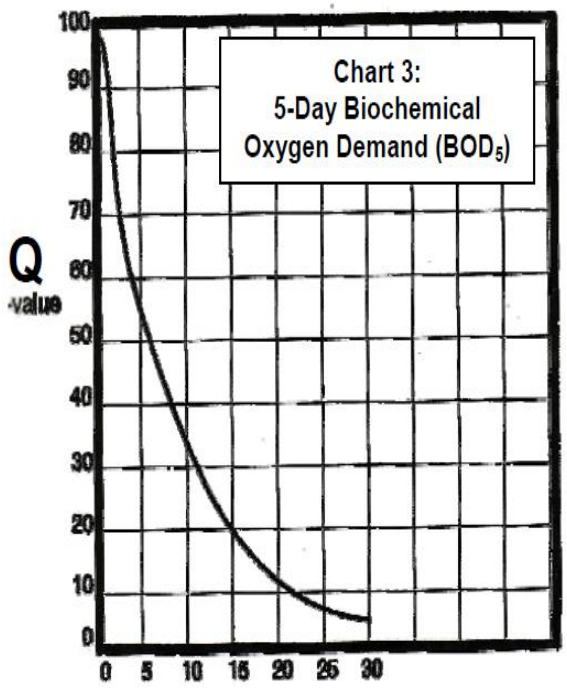

Fig-5.3 (Q-value for BOD)

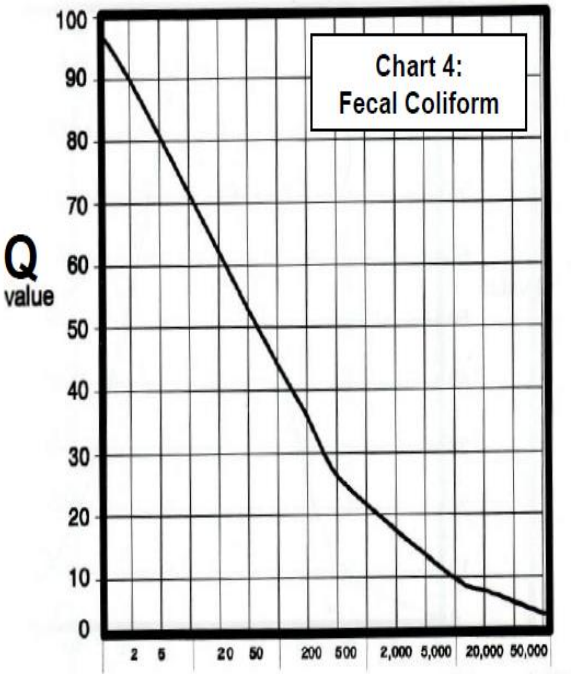

Fig-5.4 (Q-value for FC)

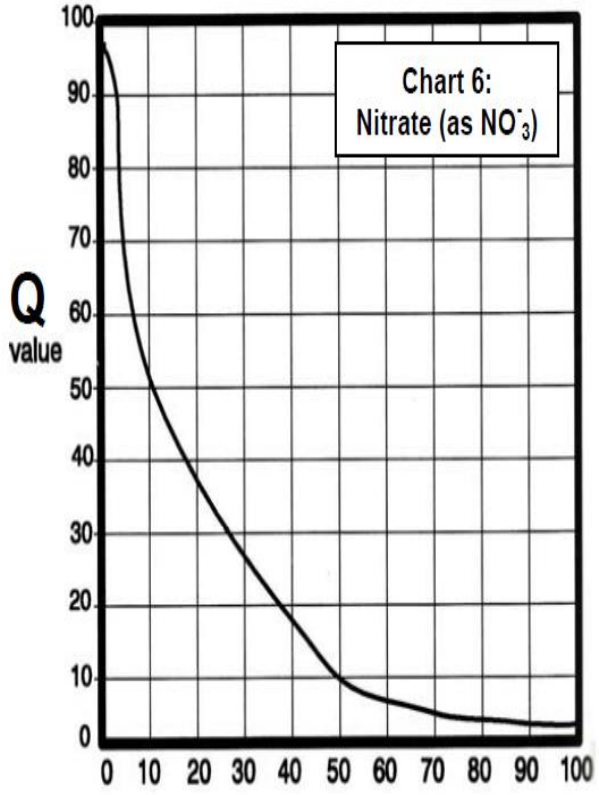

Fig-5.5 (Q-value for Nitrate)

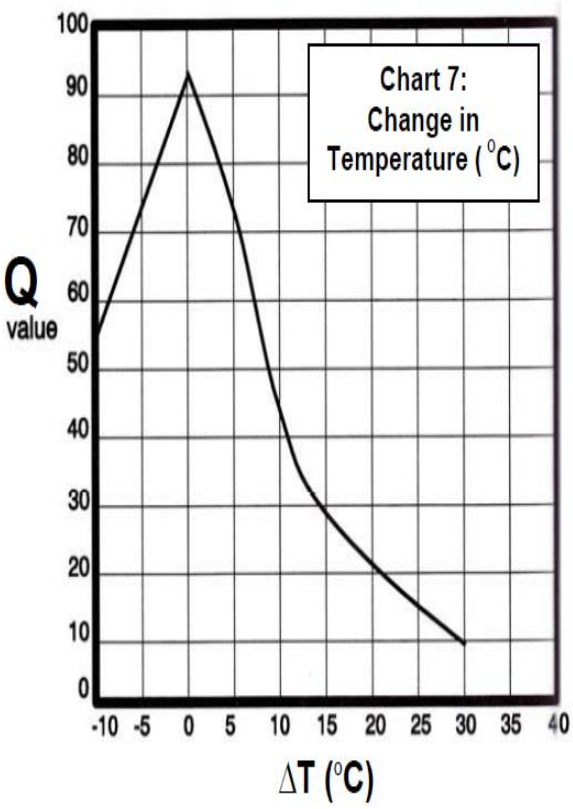

Fig-5.6 (Q-value for Temp. change)

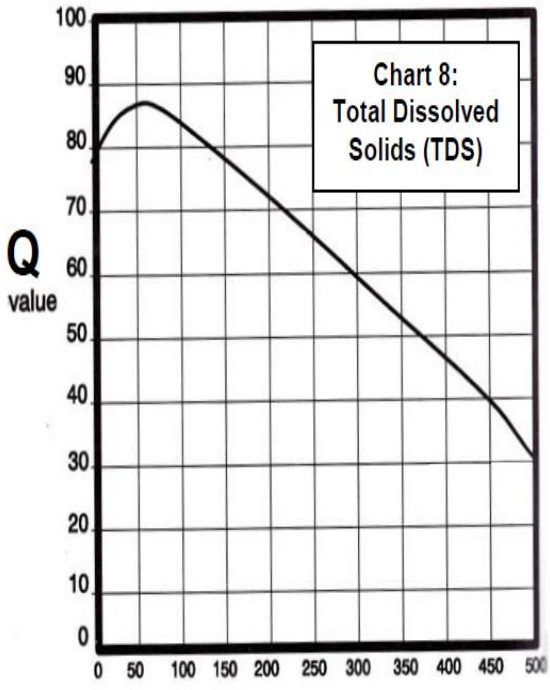

Fig-5.7 (Q-value for TDS)

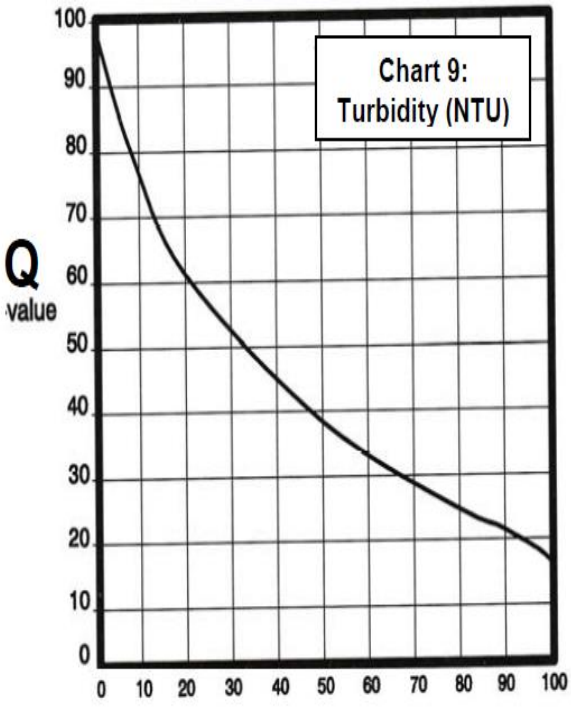

Fig-5.8 (Q-value for Turbidity)

The observation of WQI values of all the samples as per NSF-WQI method is presented in the following tables:

Table-5.13: NSF-WQI calculation of Sample-1

Parameters	Values	Qi	Wi	Qi * Wi
DO (% Saturation)	127.7	84	0.17	14.28
pH	7.87	88	0.11	9.68
BOD	2.35	82	0.11	9.02
Nitrate	14.69	44	0.1	4.4
Turbidity	51	37.7	0.08	3.016
TDS	103	84.5	0.07	5.915
Total			0.64	46.311
WQI				72.36094

Table-5.14: NSF-WQI calculation of Sample-2

Parameters	Values	Qi	Wi	Qi * Wi
DO (% Saturation)	103.8	96	0.17	16.32
pH	7.51	93	0.11	10.23
BOD	1.89	85	0.11	9.35
Nitrate	2.72	90	0.1	9
Turbidity	29	53.2	0.08	4.256
TDS	63	86	0.07	6.02
Total			0.64	55.176
WQI				86.2125

Table-5.15: NSF-WQI calculation of Sample-3

Parameters	Values	Qi	Wi	Qi * Wi
DO (% Saturation)	101.5	96.5	0.17	16.405
pH	8.25	72	0.11	7.92
BOD	1.16	95	0.11	10.45
Nitrate	12.73	48	0.1	4.8
Turbidity	58.9	33	0.08	2.64
TDS	24	84	0.07	5.88
Total			0.64	48.095
WQI				75.14844

Table-5.16: NSF-WQI calculation of Sample-4

Parameters	Values	Qi	Wi	Qi * Wi
DO (% Saturation)	82.7	88	0.17	14.96
pH	6.35	68	0.11	7.48
BOD	0.78	99.1	0.11	10.901
Nitrate	39.42	18.5	0.1	1.85
Turbidity	13.1	74.4	0.08	5.952
TDS	79	83.6	0.07	5.852
Total			0.64	46.995
WQI				73.42969

Table-5.17: NSF-WQI calculation of Sample-5

Parameters	Values	Qi	Wi	Qi * Wi
DO (% Saturation)	77.8	83	0.17	14.11
pH	6.1	57	0.11	6.27
BOD	1.72	92	0.11	10.12
Nitrate	36.39	20.5	0.1	2.05
Turbidity	59.5	32.8	0.08	2.624
TDS	65	85.7	0.07	5.999
Total			0.64	41.173
WQI				64.33281

Table-5.18: NSF-WQI calculation of Sample-6

Parameters	Values	Qi	Wi	Qi * Wi
DO (% Saturation)	93.6	94.5	0.17	16.065
pH	5.74	48	0.11	5.28
BOD	1.09	97.2	0.11	10.692
Nitrate	3.92	78	0.1	7.8
Turbidity	5.3	85	0.08	6.8
TDS	24	84	0.07	5.88
Total			0.64	52.517
WQI				82.05781

Table-5.19: NSF-WQI calculation of Sample-7

Parameters	Values	Qi	Wi	Qi * Wi
DO (% Saturation)	103	95.5	0.17	16.235
pH	6.99	87.5	0.11	9.625
BOD	1.03	97.5	0.11	10.725
Nitrate	1.05	95	0.1	9.5
Turbidity	25.6	56.2	0.08	4.496
TDS	66	85.4	0.07	5.978
Total			0.64	56.559
WQI				88.37344

Table-5.20: NSF-WQI calculation of Sample-8

Parameters	Values	Qi	Wi	Qi * Wi
DO (% Saturation)	98.1	95.7	0.17	16.269
pH	7.15	89	0.11	9.79
BOD	0.83	98.7	0.11	10.857
Nitrate	1.14	94.5	0.1	9.45
Turbidity	13.4	70	0.08	5.6
TDS	192	72.6	0.07	5.082
Total			0.64	57.048
WQI				89.1375

CHAPTER-6

DISCUSSION & CONCLUSION

6. DISCUSSION AND CONCLUSION

6.1 DISCUSSION

Noteworthy development in metal and power industry and the quick expansion of demand of crude material have upgraded degree of the mining business like at no other time. Both coal mining and metal mining have seen a tremendous change throughout the previous decades. No big surprise it has prompted development in economy and advancement of numerous areas and the nation by and large yet the toll it has tackled nature's domain and environment can't and ought not to be disregarded. The effect of mining movement on common water bodies is wide and broad. It has turned into a challenge for the business, government and the preservationist to keep the water contamination because of different mining action which may be coordinate or backhanded foundation for such contamination.

It may be observed from Table-5.2 that:

- The pH values of all the samples are within the limits except S-4 and S-5. This is possibly due to the acidic water percolating to the ground.
- Samples S-1, S-3, S-4 and S-5 have high hardness(>300) values compared to other samples.
- DO of all the samples is more than 5 mg/L.

It can also be observed from Table-5.1 that all the samples have high turbidity values.

All the samples are compared in consideration to WQI values calculated from both the methods. They are presented in the following figures:

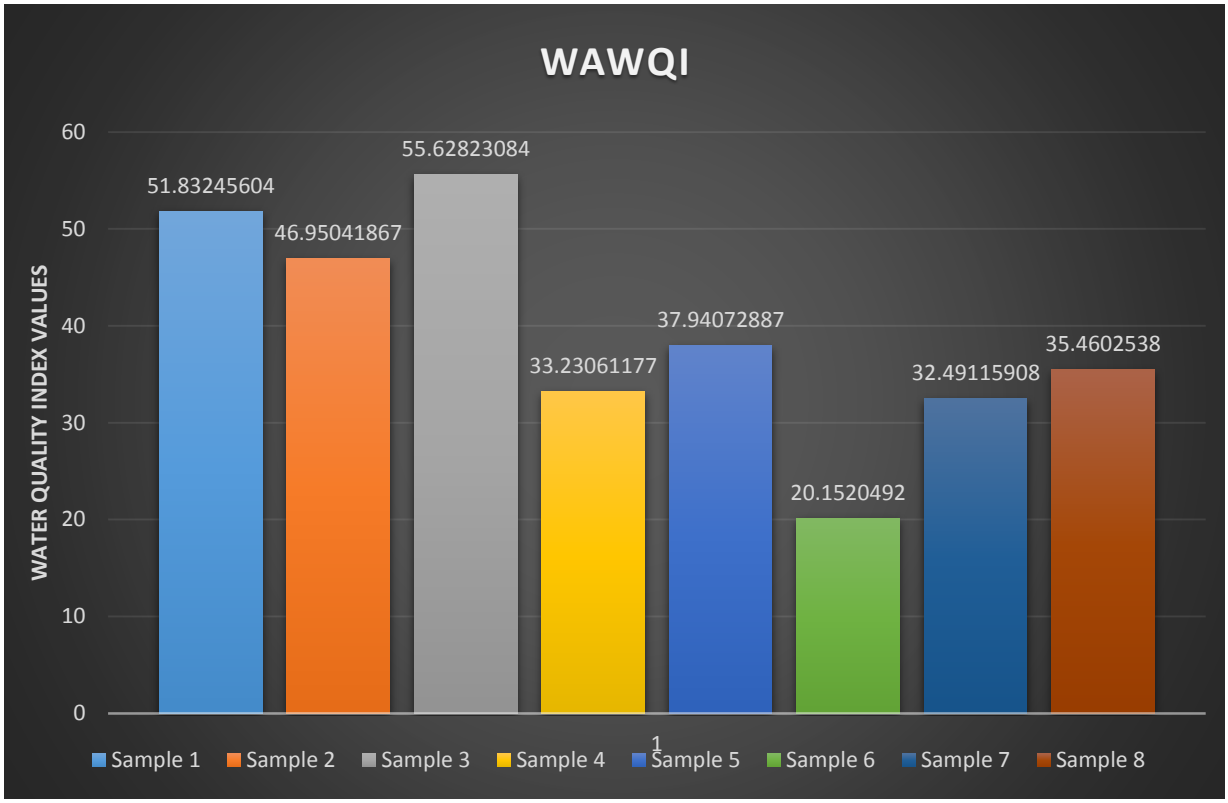

Fig-6.1: Comparision of WA-WQI of all the Samples

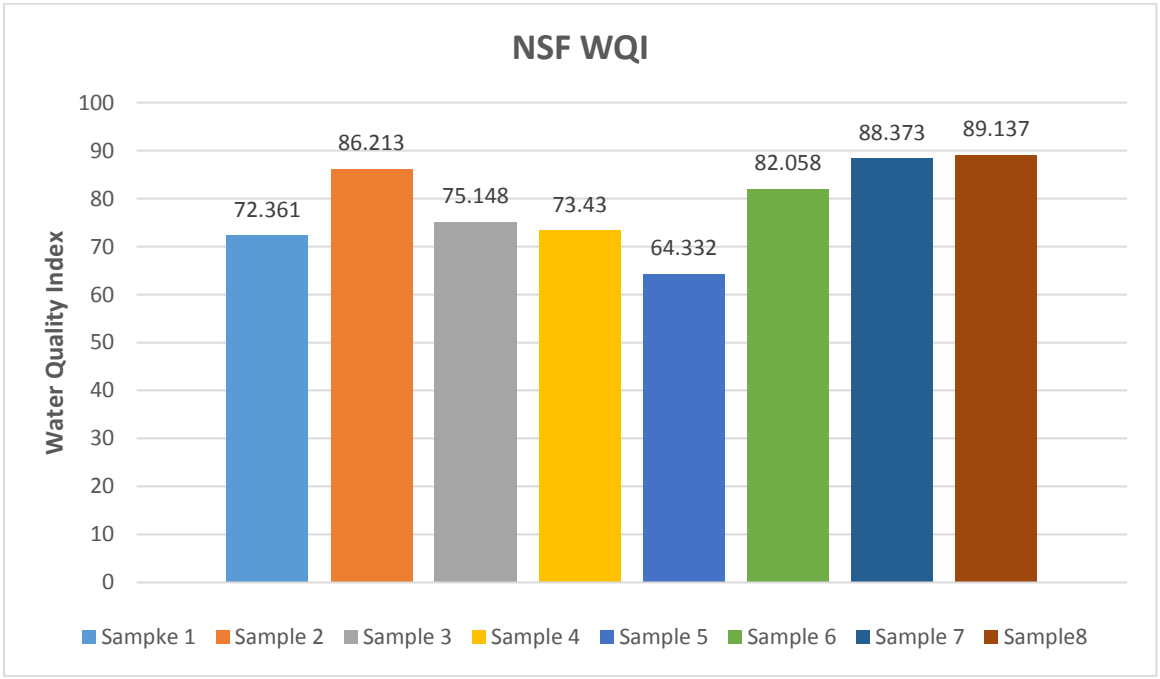

Fig-6.2: Comparision of NSF-WQI of all the Samples

It could be seen from the Fig-6.1 that the ground water is less contaminated compared to surface water.

The WQI values of samples collected from Nallah corresponds to poor quality of water present there, it couldn't be used for drinking purposes.
Water sample collected from S-3 having a WA-WQI value of 55.628 indicates its very poor in quality and should not be used without proper treatment.
As it has been told that these WQI values contradict each other sometimes. This happens because they are considering different parameters in finding out the WQI values. Even it can be seen in S-3 that it is of poor quality as per WA-WQI while it is good as per NSF-WQI.

6.2 CONCLUSION

It could be seen that the water quality has deteriorated due to mining activities. The surface water bodies have been contaminated to a significant extent compared to ground water. The study was carried out in 15 April 2014. It is expected that in rainy season there could be a significant contamination of water bodies. It is therefore highly recommended that appropriate measures are to be taken so that the water coming from mine and processing plants doesnot mix with the natural water bodies. Though some mining companies have adopted proper control measures such as construction of garland drains, mining walls, settling ponds, effluent treatment plants etc., still a lot more is required to be achieved.
The monitoring mechanism has to be more vigilant to ensure that the natural water bodies are prevented from contamination due to mining activities. This will not only prevent the health hazards but also maintain a balance of our eco-system.

CHAPTER-7

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7. REFERENCES

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